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Summary - Berseem clover (*Trifolium alexandrinum* L.) is an annual forage crop widely grown in Mediterranean environments. The accumulation of dry matter in the various plant organs, at a given growth stage, in forage legume species is a subject of biological and economic concern. The study was carried out during three growing seasons (1991-92, 1992-93 and 1993-94) at Foggia (southern Italy), with the aim of evaluating changes in the growth dynamics of one population of Egyptian (cv.'Giza 10') as well as Italian (cv.'Sacromonte') origin using field-grown plants under several cutting regimes. The harvest treatments were applied at three developmental stages of the plant: sixth internode elongation, early flowering and physiological maturity of seeds (treatments A, B and C, respectively). Seasonal growth pattern, determined as dry matter accumulation, was greatly influenced by cutting regimes. In treatment C, the maximum value (21.6 g plant^{-1} in the mean) was reached at about 250 days after sowing. Total dry matter followed the same general trend over time for both genotypes. However, the cv.'Sacromonte' showed higher values than 'Giza 10' under all treatments. Defoliation significantly influenced leaf-stem (LSR), source-sink (SSR) and shoot-root (SRR) ratios as well as plant height. The highest LSR (4.2 g g^{-1}) was reached after the first cutting under treatment A. SSR, SRR and plant height drastically decreased after cuttings in both treatments A and B. Under treatment C plants showed a decrease in LSR and SSR and an increase in SRR and plant height during the experimental period. The growth characteristics in berseem plants were greatly influenced by cutting regimes and their response varied between cultivars.

Key-words: berseem, dry matter accumulation, leaf-stem ratio, source-sink ratio, shoot-root ratio

Résumé - *Le trèfle d'Alexandrie est une espèce fourragère annuelle largement utilisée sous climat méditerranéen. Deux populations, l'une égyptienne (cv Giza10) l'autre italienne (cv Sacromonte) ont été comparées pendant 3 saisons de végétation à Foggia (Italie du sud), en réponse à différents régime de coupe. Les 3 stades de coupe étudiés sont : A/ 6° entre-nœud, B/ début de floraison et C/ maturité des semences. La production saisonnière a été fortement influencée par le régime de coupe. La phytomasse totale suit les mêmes tendances pour les deux cultivars, mais Sacromonte atteint des rendements plus élevés. La défoliation a un effet significatif sur les rapports feuille/tige (FT), source/puits (SP), pousse/racine (PR) comme sur la hauteur des plantes. Le meilleur FT correspond à la première coupe mais les trois indices chutent fortement dans les traitements A et B. C diminue FT et SP mais augmente PR et la hauteur des plantes.*

Mots-clès: *bersim, productivité, rapport feuille/tige, rapport source/puits, rapport pousse/racine*

Introduction

Berseem clover (*Trifolium alexandrinum* L.) is an annual leguminous forage species well adapted to semi-arid conditions of the Mediterranean areas. Harvest management is the agronomic factor that most affects plant physiology and the expression of the yield potential of a genotype. In fact, dry matter production and its partitioning in the plant organs depend on the phenological stage of development in which plants are cut (Iannucci *et al.*, 1996). Hence, harvest management of berseem can be manipulated to redistribute yield and achieve forage quality goals without sacrificing stand persistence. Furthermore, the knowledge of growth patterns and productivity under different cutting regimes is of primary importance in the berseem breeding programs.

Our objective was to determine the effect of different cutting regimes on growth dynamics in two berseem cultivars of different geographical origin.

Materials and methods

Field experiments were carried out at the Forage Crop Institute farm located in Foggia (southern Italy: 15°33'E, 41°31'N; 76 m above sea level) during 1991-92, 1992-93, 1993-94 growing seasons. Two berseem cultivars of different geographical origin, 'Giza 10' (Egyptian) and 'Sacromonte' (Italian), were evaluated. Cutting treatments were applied at three different plant ages: sixth internode elongation (A), early flowering (B) and physiological maturity of seeds (C). During the experimental period two cuts were applied in both treatments A and B.

Seeds were sown in jiffypots (5 cm in diameter) in a cold glasshouse. After germination seedlings were thinned to one per jiffypot and at the three-leaf stage of development were transplanted to field plots, which consisted of 3 rows 0.5 m long and 30 cm apart with 10 plants per row. Plants within a row were separated by a plastic grid.

Starting from fifth internode elongation (about 196 days after sowing) until physiological maturity in the case of uncut plants (about 257 days after sowing), 12 destructive harvests were made at 5- to 6- day intervals in all cutting treatments. Plants of the central row of a plot were removed from the soil and the roots were washed. Then the plants were individually separated into stems, leaves, heads, crowns (cotyledonary node to 5 cm above) and roots (cotyledonary node to 15 cm below). Dry weights were recorded after drying in a forced-drought oven at 60° C for 48 h. Plant height was also measured.

Leaf-stem (LSR), source-sink (leaf/sum of the other plant parts - SSR) and shoot-root (sum of aerial plant parts/root - SRR) ratios were calculated from dry weights.

Data were analyzed as a randomized complete block design with a split-split-plot arrangement. Species were main-plots, cutting treatments sub-plot, and harvest dates sub-sub-plots. Analysis of variance was performed for each cutting treatment separately. Mean separations were made by Fisher's LSD test at the 0.05 probability level.

Results and discussion

The developmental stage at cut greatly influenced dry matter accumulation in both cultivars (Fig. 1).

As expected, there was a considerable reduction in dry matter production under treatments A and B. Furthermore, in these treatments, the second cut values were lower than those of the first. At outset, all plants were of similar size, but by the end of the experiment, plant size ranged from 21.0 g plant^{-1} (treatment C) to 2.5 g plant^{-1} (treatment B) in the mean. So, delaying cutting from sixth internode elongation until flowering resulted in a subsequent depression in herbage yield. Similar results have been reported for other species (Pohlmann and Simon, 1993; Xia *et al.*, 1993).

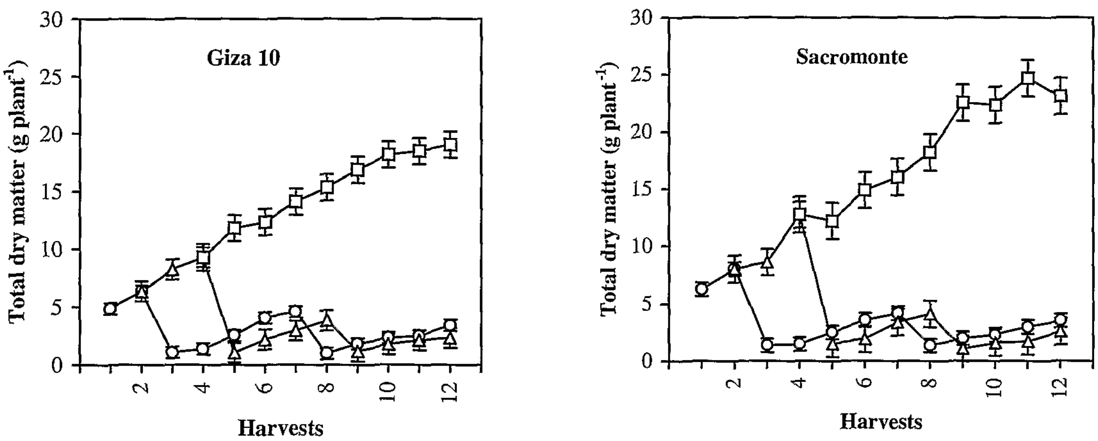

Fig 1. Dry matter accumulation patterns for Giza 10 and Sacromonte under three cutting regimes (A O—O, sixth internode elongation; B Δ—Δ, early flowering; C □—□, physiological maturity). Data are means for 3 years. Vertical lines indicate ± SEM.

Total dry matter accumulation during the growing season followed the same general pattern for both genotypes. However, the cultivar 'Sacromonte' showed always higher values than 'Giza 10' in all cutting treatments. At the first cut of treatment A the difference in aerial biomass production was 26% and at the first cut of treatment B this difference increased to 37%. This reflects the higher growth capacity of 'Sacromonte' during early spring in comparison to 'Giza 10'. Under treatment C maximum values of dry matter were 18.5 g plant^{-1} and 24.7 g plant^{-1} for 'Giza 10' and 'Sacromonte', respectively, and were reached at about 250 days after sowing for both cultivars. This is in agreement with Martiniello *et al.* (1996) who reported that the berseem genotypes of Italian origin were more productive than Egyptian genotypes when harvested at physiological maturity.

Cutting regimes significantly influenced the partitioning of the assimilates among different plant organs as well as plant height (Table 1).

In treatment A, after 12 days from cutting LSR increased to maximum values of 4.2 and 1.3 g g^{-1} for the first and the second cuttings, respectively, and then decreased. Under treatment B, LSR was not statistically significant during the experimental period but showed the same pattern as treatment A. Defoliation caused a considerable reduction in SSR, SRR and plant height under both treatments A and B. Without defoliation (treatment C) plants showed a progressive decrease in LSR and SSR and an increase in SRR during the experimental period. In particular, LSR and SSR reached 50% of the initial value after about 240 days after sowing (harvest 9). The rapid decline in these ratios after this time could be related to leaf senescence and/or to the high demand for photosynthate during seed formation. Similar results have been reported in annual *Medicago* species (Dekaoui *et al.*, 1990). Furthermore, SRR doubled from the first to twelfth harvests and plant height reached 90% of the final value 236 days after sowing (harvest 8).

Table 1. Leaf-stem ratio, source-sink ratio, shoot-root ratio and plant height at each harvest for three cutting treatments. Means are for 3 years and 2 cultivars.

Harvest	Leaf-stem ratio			Source-sink ratio			Shoot-root ratio			Plant height		
	A†	B	C	A	B	C	A	B	C	A	B	C
No.	g g^{-1}									cm		
1	1.01	1.01	1.01	0.66	0.66	0.66	18.0	18.0	18.0	47.3	47.3	47.3
2	0.91	0.91	0.91	0.64	0.64	0.64	20.7	20.7	20.7	55.4	55.4	55.4
3	2.70	0.87	0.87	0.23	0.64	0.64	4.2	21.1	21.1	10.8	62.2	62.2
4	4.19	0.84	0.84	0.41	0.64	0.64	4.7	25.7	25.7	18.6	71.0	71.0
5	1.61	1.28	0.76	0.54	0.17	0.59	7.0	3.7	27.9	31.3	10.4	78.0
6	1.18	1.71	0.71	0.55	0.36	0.55	10.0	5.7	29.6	47.2	23.0	82.9
7	0.83	1.16	0.63	0.45	0.45	0.48	11.2	7.9	31.9	54.4	37.8	87.0
8	0.96	0.96	0.61	0.13	0.44	0.44	3.4	8.8	33.1	9.3	43.4	90.0
9	1.30	1.88	0.52	0.29	0.12	0.36	4.8	3.5	36.8	18.9	9.0	94.0
10	1.11	2.57	0.44	0.29	0.19	0.29	5.6	4.2	35.9	22.6	12.6	94.4
11	0.96	2.45	0.41	0.26	0.18	0.26	6.5	3.3	39.3	28.6	16.9	97.4
12	0.76	1.42	0.35	0.23	0.18	0.21	8.3	4.1	39.6	35.3	23.2	99.5
$LSD_{(0.05)}$	1.58	NS	0.09	0.14	0.09	0.07	4.8	4.9	3.1	10.4	9.2	4.0

†A= cutting applied at the sixth internode elongation, corresponding to harvests 2 and 7; B= cutting applied at early flowering, corresponding to harvests 4 and 8; C= no cutting applied until physiological maturity.

Conclusions

This experiment showed that growth characteristics in berseem plants were greatly affected by cutting regimes and that their response varied between cultivars.

Under treatment C, plants grew rapidly throughout the experimental period, whereas under other treatments plants rapidly produced new leaves following defoliation, although this recovery was not sufficient to reach the initial level of total dry matter.

The differences in accumulated dry matter partitioning due to the several cutting regimes applied resulted in significant changes in leaf-stem, source-sink and shoot-root ratios. Furthermore, the partitioning of assimilates between shoots and roots varied between cuts within each treatment and led to significant differences in harvestable biomass.

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